PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : C08J 9/04, B65D 1/26 // C08L 23:10 — A1

(11) International Publication Number: **WO 97/29150**

(43) International Publication Date: 14 August 1997 (14.08.97)

(21) International Application Number: PCT/EP97/00420

(22) International Filing Date: 31 January 1997 (31.01.97)

(30) Priority Data:
318/96 7 February 1996 (07.02.96) CH

(71) Applicant *(for all designated States except US)*: CONVENIENCE FOOD SYSTEMS B.V. [NL/NL]; Beekakker 11, NL-5761 En Bakel (NL).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: ROLLE, Jean-Claude [CH/CH]; 15, rue Pierre-Alex, CH-1630 Bulle (CH). PITTET, Michel [CH/CH]; Route de l'Ancien-Stand, CH-1680 Romont (CH).

(74) Agent: FREI PATENTANWALTSBÜRO; Postfach 768, CH-8029 Zürich (CH).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: THERMOFORMABLE FOAM SHEETING FOR PRODUCING OPEN CONTAINERS

(57) Abstract

The invention relates to a thermoformable sheeting consisting of a foam material or containing at least one layer of a foam material. The inventive sheeting is particularly applicable for thermoforming cups or trays for packaging and/or consuming food stuffs, by drawing or deep drawing the sheeting and expanding the foam material. The foam material of the inventive sheeting consists of a polypropylene blend containing between 50 and 100 % of high melt strength polypropylene, has a density of 0.1 to 0.7 g/cm^3, preferably between 0.25 and 0.5 g/cm^3, and a cell number of from greater than 300 to 3000 cells per mm^3, preferably between 800 and 2500 cells per mm^3. The inventive sheeting can be drawn with a high drawing ratio (e.g. 1.5) and expanded to be formed into containers even with difficult shapes, whereby no drawing problems arise and the containers produced show a homogeneous opaqueness.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgystan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic			SE	Sweden
CG	Congo	KR	Republic of Korea	SG	Singapore
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LR	Liberia	SZ	Swaziland
CS	Czechoslovakia	LT	Lithuania	TD	Chad
CZ	Czech Republic	LU	Luxembourg	TG	Togo
DE	Germany	LV	Latvia	TJ	Tajikistan
DK	Denmark	MC	Monaco	TT	Trinidad and Tobago
EE	Estonia	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	UG	Uganda
FI	Finland	ML	Mali	US	United States of America
FR	France	MN	Mongolia	UZ	Uzbekistan
GA	Gabon	MR	Mauritania	VN	Viet Nam

THERMOFORMABLE FOAM SHEETING FOR PRODUCING OPEN CONTAINERS

The invention is in the field of the packaging industry and relates to a thermoformable foam sheeting according to the generic part of the first independent claim, which sheeting consists of a thermoformable and expandable foam material or contains at least one layer of such a material.

Open containers, such as e.g. trays or cups often used for packaging and/or for consuming food stuffs are usually produced by drawing or deep drawing a piece of flat sheeting made of a thermoformable plastic material. Such open containers have a bottom wall and a side wall or side walls. The sheeting is usually thermoformed between a pair of forming tools, i.e. between a female tool with a recess over which the preheated sheeting is positioned and a male tool movable into the recess of the female tool thereby drawing the sheeting.

The use of a sheeting consisting of a foamed material or containing at least one layer of a foamed material is advantageous for making such containers because a foam sheet or a container made of such a sheet unit is usually stiffer than the corresponding solid material with the same weight per area. Sheeting and containers consisting at least partly of foamed material are

opaque. The containers need a minimum mechanical strength according to their application and they are the better accepted, the more homogeneous their opaqueness and the smoother and shinier their surface is.

A further advantage of producing the open containers of a sheeting which consists of a foamed material or contains at least one layer of such a material, is the possibility of expanding specific parts of the container walls by applying a reduced pressure to the foam when it is in a thermoformable state, whereby the gas trapped in the foam expands, and by cooling down the foam when still under reduced pressure. Such processes are described e.g. in the publications US-3846526 or JP-60192615. Furthermore, a method and an apparatus for drawing and expanding foam sheeting to form open containers is described in a co-pending application (same filing date as the present application).

According to the co-pending application the containers are formed with the help of a male tool moving into the recess of a female tool and thereby drawing the preheated sheeting positioned over the recess of the female tool. During the movement of the male tool the pressure on at least one side of the sheeting is reduced such that it reaches a value (expansion pressure) below ambient pressure which is low enough for expanding the foam material when the male tool reaches its end position or immediately afterwards. The tools are then kept in the end position and expansion pressure is maintained until the sheeting has cooled down to a temperature below its plastication temperature. Then the formed container is demolded. Before the moving male tool contacts the preheated sheeting, the sheeting may be prestretched by applying a pressure difference to it (lower pressure on the female tool side). Such prestretching is preferable in particular when producing containers by deep drawing (drawing ratio > 1) and/or containers with a difficult shape (not round bottom wall, steep side walls).

With the method described in the last paragraph and using tools which have, for removing air from between the sheeting and the tool surface, a pattern of openings on at least those parts of their surface which are to form the side walls of the container (as described in a further co-pending application with the same application date as the present application), it is possible to produce in a minimum cycle time from a sheeting at least partly consisting of foamed material, open containers with a wall thickness and wall density which are primarily determined by the mechanical properties the container is to have. This means that the container wall may have, according to the degree of drawing and of expansion a varying thickness and in particular a varying density.

Using known sheetings consisting of or containing e.g. polystyrene or polypropylene foam for producing open containers according to the above described method, may create problems in that on the produced containers areas of varying degree of drawing and/or expansion show optically or even lead to mechanical faults which happens in particular when the cycle time is short and/or the drawing ratio is high or the shape of the container is difficult, as are e.g. container shapes with a non-round bottom wall and/or with very steep side walls.

It is therefore the object of the invention to create a sheeting consisting of a foamed material or containing at least one layer of a foamed material which sheeting has good drawing characteristics and an opaqueness which varies little with density such that the sheeting can be processed using the method of the co-pending application in particular with very short cycle times and with high drawing ratios and difficult container shapes resulting in containers which are mechanically and estheticly of good quality. In addition, the sheeting as

well as the containers made from the sheeting are to be easily recyclable and compatible with food stuffs of a variety as wide as possible (solid and liquid, hot and cold etc.).

This object is achieved by the sheeting as defined by the claims.

For fulfilling the condition of the recyclability and the food compatibility, the inventive sheeting consists basically of polypropylene. This means it consists fully of a polypropylene foam or contains at least one layer of polypropylene foam and contains a further layer or further layers e.g. of solid polypropylene or of other termoformable materials, e.g. barrier materials.

The opaqueness of a plastic foam material is due to light scattering on the cell walls. The finer the arrangement of these cell walls is, the more times light falling into the material is scattered and the more opaque does the material appear. It is found that the finer the arrangement of the cell walls, the less does the appearance of the material change when drawn and/or expanded to quite a high degree. It is found also that the finer the arrangement of the cell walls the better are the drawing characteristics of the foam. This is due to the fact, that the occurrence of cells which are large enough for locally changing the drawability of the foam to a considerable degree and for being torn open upon drawing, gets more probable as the cell size increases, i.e. as the fineness of the cell wall structure decreases.

The measure for the fineness of the cell wall structure in a plastic foam material is the cell number (cells per mm^3). It is found that sheetings with polypropylene foams having a cell number which is higher than 300 cells per

mm^3 and processed in the method according to the co-pending application give good quality containers for a relatively low drawing ratio (container depth divided by diameter of opening: between 0.5 and 1, depending on container shape and expansion ratio). Sheeting with polypropylene foam with a cell number of up to 3000 cells per mm^3 gives good quality containers for drawing ratios of 0.8 to 1.5 (depending on container shape and expansion ratio). For the production of containers such as cups and trays for packaging and/or consuming food stuffs in a drawing process as described in the co-pending application, sheeting with polypropylene foam having a cell number of 800 to 2500 cells per mm^3, preferably of 1000 to 2000 cells per mm^3, is very suitable.

The polypropylene foam of the inventive sheeting has a density of 0.1 to 0.7 gr/cm^3, preferably of 0.25 to 0.5 gr/cm^3, even more preferably of 0.36 to 0.50 gr/cm^3. The sheeting has a thickness of 0.5 to 3 mm, preferably of 1 to 2 mm and even more preferably of 1.2 to 1.6 mm.

If, depending on the density of the polypropylene foam and on the thickness of the sheeting to be made, a polypropylene blend containing between 50 and 100% of high melt strength polypropylene with a melt strength of ca. 24 cN is used, extrusion of a sheeting with the above mentioned characteristics is possible without problem. High melt strength polypropylene (polypropylene with long chain branching) is available on the market as homopolymer or as copolymer.

The higher the melt strength of the polypropylene blend (i.e. the higher its content of high melt strength polypropylene), the easier it is to produce good quality sheeting with the required cell numbers. However, because a high

percentage of high melt strength polypropylene is not only an economic drawback but also results in containers with rather brittle walls, it is advantageous to lower the percentage of high melt strength polypropylene as much as possible towards 50%, by adding other types of polypropylene (homo- or copolymers) thereby lowering the melt strength of the blend to as low as 15 cN, preferably to between 18 and 20 cN.

A sheeting applicable in the thermoforming method according to the co-pending application for producing cups and trays for packaging and/or consuming food which cups and trays have a mechanical stability suitable for this purpose, preferably consists of or contains a polypropylene foam containing 60 to 90%, preferably 60 to 80% of high melt strength polypropylene.

For producing by extrusion the sheeting consisting of or containing the polypropylene foam, a solid or gaseous blowing agent is added to the polymer blend in a known manner. Furthermore other known additives for improving the extrusion process may be added in known concentrations as well as e.g. pigments for coloring the foam material.

The cell number of an extruded foam material is not only dependent on the composition of the extruded polymer and on the additives used but also on the extrusion parameters. Therefore, for producing a sheeting with a polypropylene foam of the composition given above and having a cell number within a predetermined range, the appropriate extrusion parameters are to be determined by experiment.

Example:

sheeting:

polypropylene blend: 80% of high melt strength polypropylene, 20% of polypropylene copolymer

additives: 1,1% blowing agent

thickness of foam: 1.4 mm

density: 0.43 g/cm^3

cell number: 1450 cells per mm^3

thermoforming process with prestretching:

width of cavity: 1.2 mm

sheet temperature: ≥ 160°C

expansion pressure: ≤ 0.2 bar (absolute)

forming time (prestretching, drawing and expansion): 1.8 sec

container made from the sheeting:

round cup: diameter of opening: 75 mm

depth: 80 mm

wall thickness: 1 - 1.2 mm

CLAIMS

1. Thermoformable sheeting which sheeting consists of a polypropylene foam or contains at least one layer of such a foam and which sheeting is applicable for producing open containers by drawing or deep drawing the sheeting and expanding the foam material, **characterized** in that the polypropylene foam consists of a polypropylene blend containing between 50 and 100% high melt strength polypropylene, has a density of 0.1 to 0.7 g/cm^3 and a cell number of more than 300 cells per mm^3.

2. Thermoformable sheeting according to claim 1, **characterized** in that the foam has a cell number of 800 to 2500 cells per mm^3.

3. Thermoformable sheeting according to claim 1, **characterized** in that the foam has a cell number of 1000 to 2000 cells per mm^3.

4. Thermoformable sheeting according to claim 1, **characterized** in that the polypropylene blend consists of 60 to 90% of high melt strength propylene-homopolymer or -copolymer and at least one further propylene-homopolymer or -copolymer.

5. Thermoformable sheeting according to claim 1, **characterized** in that the polypropylene blend consists of 60 to 80% of high melt strength

propylene-homopolymer or -copolymer and of at least one further propylene-homopolymer or -copolymer.

6. Thermoformable sheeting according to claim 1, **characterized** in that the polypropylene foam has a density of 0.25 to 0.5 gr/cm^3.

7. Thermoformable sheeting according to claim 1, **characterized** in that the polypropylene foam has a density of 0.36 to 0.50 gr/cm^3.

8. Thermoformable sheeting according to claim 1, **characterized** in that the sheeting or the at least one foam layer has a thickness of between 0.5 and 3 mm.

9. Thermoformable sheeting according to claim 1, **characterized** in that she sheeting or the at least one foam layer has a thickness of between 1 to 2 mm.

10. Thermoformable sheeting according to claim 1, **characterized** in that she sheeting or the at least one foam layer has a thickness of between 1.2 to 1.6 mm.

11. Thermoformable sheeting according to claim 1, **characterized** in that it has a thickness of 1.4 mm and consists of a polypropylene foam containing 80% of high melt strength polypropylene having a density of 0.43 g/cm^3 and a cell number of 1450 cells per mm^3.

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PC1,EP 97/00420

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C08J9/04 B65D1/26 //C08L23:10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C08J B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 438 874 A (TONEN SEKIYUKAGAKU KK) 31 July 1991 see page 5, line 47-52 see page 14-15; example 11; table 3 see claims ---	1-11
A	US 4 680 317 A (KUEHNEL WERNER ET AL) 14 July 1987 see claims ---	1-11
A	EP 0 458 731 A (MITSUBISHI PETROCHEMICAL CO) 27 November 1991 see page 15; examples 8,2 see page 9, line 20 see claims --- -/--	1-11

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

2

Date of the actual completion of the international search	Date of mailing of the international search report
26 May 1997	- 6. 06. 97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Oudot, R

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Intern· ·al Application No
PC1/EP 97/00420

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category '	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 871 897 A (EALDING CYRIL JOHN) 18 March 1975 see example 3 see claims -----	1-11

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

ational Application No
PCT/EP 97/00420

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0438874 A	31-07-91	JP 3177436 A	01-08-91
		JP 3192133 A	22-08-91
US 4680317 A	14-07-87	DE 3132439 A	10-03-83
		EP 0072444 A	23-02-83
EP 0458731 A	27-11-91	JP 4028706 A	31-01-92
		US 5262503 A	16-11-93
US 3871897 A	18-03-75	US 3839238 A	01-10-74